THE WORK OF CHILDREN: SEEKING PATTERNS IN THE DESIGN OF EDUCATIONAL TECHNOLOGY

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ABSTRACT

The vast majority of research in educational technology focuses, justifiably, on what might be described as "short-term" (or perhaps "medium-term") questions: how to improve an existing software system, how to assess a particular classroom innovation, how to teach some current subject matter in a more effective fashion. From time to time, however, it is worth stepping back from such questions and taking a longer view of children's technology: what are the larger patterns by which certain technologies become associated with children's work? In this paper, we examine a broad thematic pattern through which "adult" (or "professional") technologies become progressively associated with children's activities. As an example of how this analysis can be put to use for future design, we describe early steps in an effort to adapt a particularly powerful manufacturing technology ("pick-and-place") for children's crafts.

KEYWORDS

Educational computing, educational 3D printing, children's pick-and-place device.

1. INTRODUCTION: TECHNOLOGIES FOR CHILDREN'S WORK

In the main, when researchers write about educational (or children's) technology, they have a specific technology in mind (e.g., desktop computers, handheld devices, Arduino microprocessors, to name just a few). In the same vein, these researchers tend to have a specific *goal* in mind as well: how to improve the teaching of geometry, how to make a particular interface more usable, how to teach children to program. This approach is a staple of educational technology research, and deservedly so: it represents the means by which steady progress is made in the field at large.

At the same time, however, it is occasionally worthwhile to stand back and take a longer view of children's technology–to look at patterns that play out over a period of decades or longer in the landscape of tools, techniques, and materials available to children. From the vantage point of the present, children are often described as "naturally drawn" to devices such as computers: there is a default assumption, in adult discourse, that children acquire a level of comfort with novel technologies that is unavailable to their hidebound elders. It wasn't always so, at least in the case of computers. In John Markoff's [2005] book *What the Dormouse Said*, focusing on the early history (and pre-history) of the personal computing era, he writes about a former aerospace engineer, Bob Albrecht, who taught Fortran programming to children in the 1960's:

> Along with his other chores, [Albrecht] began to teach a small group of high school students how to program... The class became extremely popular, and soon the University of Colorado was offering an extension program that involved more than one hundred high school kids. Albrecht took his class on tour, at one point accompanying some of his students from the original Denver school to a National Computer Conference meeting. There they demonstrated their programming skills on the CDC 160 machine, shocking the high priests of computing. At the general conference meeting, there were subsequent complaints that someone had even considered turning children loose on computers! [Markoff, p. 181]

This anecdote is worth quoting at some length because it is remarkable to reflect on how the conventional wisdom has been almost completely inverted in a mere half century. The attitude of Markoff's "high priests" was born of an assumption about what technologies were appropriate for adults–more specifically, for adult

professionals–and what technologies were "for children". Since computers were highly expensive instruments, programmed at the time by trained technicians, it was unthinkable for children to use them.

Before we take too condescending an attitude toward the prejudices of the "high priests", we might wish to reflect on our own present-day assumptions of which technologies belong, or do not belong, to the realm of children's work. For the computer professionals described by Markoff, setting children loose on computers was anxiety provoking as, among other things, a matter of cost: these things are expensive! What if the kids touch the wrong toggle switch and (heaven forbid) *break* them? Looking at the current landscape of professional technologies, it is not hard to ferret out similar reflexes within ourselves. Should children, for example, be permitted to play with a high-speed camera? With an electron microscope? With a supercollider? Note that in such scenarios, the immediate concern is not primarily for the safety of the *child*: we don't expect that the child will be hurt by (say) the electron microscope toppling on her. Rather, the concern is for the safety of the *device*. A child working with an electron microscope? Absolutely not: these things are expensive.

The purpose of this paper is to explore, at least in an initial and tentative way, several of the issues raised by Markoff's anecdote, and by reflections on the long-term development of children's technology. To state our thesis briefly: there has been a recurring pattern over the past century or more of technological transition, from *professional* or *industrial* technologies to children's technologies. The most prominent example of this pattern is the computer, but the same thematic trends can be identified with other technologies–the camera, the color inkjet printer, and (a recent and striking case) the 3D printer. Repeatedly, technologies that were formerly associated with specialized professional training have come to be used by children. In many cases, the barriers to be crossed were both economic (making the technologies cheaper) and cultural (re-imagining the potential interests and abilities of children). It is our belief that by examining these historical patterns, we can spark our imagination toward the creation of novel, unexpected technologies for children's expressivity. In the final section of this paper, we outline our own early steps toward employing this design heuristic for the creation of a novel, child-focused version of the (hitherto industrial) pick-and-place machine.

2. THE TRANSITION FROM PROFESSIONAL TO CHILDREN'S TECHNOLOGY: KEY THEMES

The previous paragraph sketched the foundations of a recurring pattern in the evolution of children's technology. In this section, we expand on that basic pattern by finding commonalities and contrasts with the work of other researchers.

2.1 Leisure-oriented Technologies for Adults

In one sense, the appropriation of professional technologies by youngsters might be interpreted as simply a by-product of a larger phenomenon by which such technologies are "democratized" more generally (cf. Mumford [1934], p. 278). After all, not only do modern-day children use computers, but so do adults of all ages, and for an endless variety of (serious and "non-serious") purposes. Thus, we might argue that it is primarily *adults*, not children, that have led the way in the de-professionalization of computing technology. In the more recent case of 3D printing, children are being introduced to the technology in tandem with its adoption by the "maker movement" of hobbyists and amateur builders. In such cases, then, we might argue that the real phenomenon of interest is the (adult) movement of professional activities toward independent, leisure-oriented uses.

Some of these themes are suggested by Rachel Manes' [2009] *Hedonizing Technologies*, an indispensable book-length treatment of the transition of certain activities from industrial to leisure contexts. Manes' focus is almost exclusively on adults, with a focus on the (primarily female) audience for textile crafts such as knitting and embroidery. Manes coins the term "hedonizing" to denote the process by which formerly work-related activities become pursued primarily for fun, as hobbies. Her discussion of the process is especially perceptive, and suggests some avenues of continuity with children's technology: "Unlike industrial workers, hobby artisans have complete control over what tools and materials they use, and since efficiency of production and marketability of product are rarely issues, they buy or make the tools and materials they most enjoy using. Leisure theory and sociological sources illuminate the kinds of pleasures artisans experience in

their craft, which include control and mastery, the beauty or the individuality of the product, the sensual enjoyment of the task...the escapist quality of immersion in voluntarily chosen work, and socialization opportunities with other crafts enthusiasts." [Manes, 2009, pp. 13-14]

Clearly there are parallels here with the transitions common to children's technology; but there are also interesting points of difference. For one thing, as Manes notes, many of the hedonized technologies whose history she traces are in fact not *state-of-the-art* industrial technologies, but rather *old-fashioned* technologies made obsolete by the process of high-volume industrialization. Thus, leisure-oriented textile work represented a pleasurable return to an older, pre-factory style of activity; and one can identify (as Manes notes [p. 122]) an element of nostalgia in at least some instances of democratized technology.

With children, the emphasis is different. Youngsters, after all, are not particularly given to nostalgia; and often, the cultural emphasis in adapting professional technologies for kids is expressly to celebrate the very novelty of the technology, and quite possibly the presumed job skills associated with its mastery. (No parent would object to his child's playing with 3D printers on the grounds of the devices' uselessness or obsolescence.) Moreover, even when focusing on (say) computers, the re-thinking of the professional technology has a somewhat different flavor when the audience is composed of children. A particularly vexing element is the sometimes tense relationship between true leisure activity for children–what one might call the "hedonized" version of children's computing–and school or classroom usage. A "child's computer" might look like a somewhat different instrument when associated with home or hobbyist usage and with classroom usage. Adult leisure technologies rarely exhibit this kind of dual vision in the lives of their users.

2.2 Consumer Technologies and Creative Technologies

A second theme worth touching upon in this discussion is the distinction between certain types of *consumer* technologies for children (notably television, electronic toys, and video games), and technologies that, adopted from professional settings, thereby expand the presumed capacities and expressive range of children. To interpret the distinction in a somewhat broad-brush way, the advent of children's radio (cf. Cross [1997], p. 107) or television shows, while of historical interest, is not an especially apt example of the pattern we are focusing on in this paper. In these consumer-oriented cases, some advanced technology is adopted primarily for children's play, entertainment, or education; but there is no reason to think that children are modeling or re-inventing professional or adult creative activities for themselves.

To put the distinction in a slightly different way, and focusing on the example of television: adult anxiety about children's television might be said to focus on (mental or emotional) safety concerns. Is the programming appropriate for children? Are shows too violent or disturbing? Are they harming the child's attention span? These are the sorts of arguments that have historically raged around children's television (and have been revived in the case of video games), but they have a different flavor than the anxiety of Markoff's earlier-mentioned "high priests", who were focused on the safety of the *device*. No one worries that a child watching television is potentially risky for the TV; and by and large, the worry is that television will "dumb children down", rather than expect too much of them.

For an illuminating contrast with children's consumer technologies, consider the physicist Freeman Dyson's [2015] advocacy for placing the tools of current-day biotechnology in the hands of children: "The final step in the domestication of biotechnology will be biotech games, designed like computer games for children down to kindergarten age but played with real eggs and seed rather than images on a screen. Playing such games, kids will acquire an intimate feeling for the organisms that they are growing." [Dyson, 2015, p. 3] Dyson's vision may or may not sound desirable (or practical) to some readers, but it fits squarely within the (anxiety-provoking) pattern of adopting advanced professional technologies to empower children.

2.3 Fantasy (Imitative) Technologies and Child-adapted Technologies

A final theme worth mentioning here is that there is a subtle, and not always clear-cut, distinction in this discussion between children's technology as unexpectedly appropriated by children (as in the case of the computer, or 3D printer), and children's artifacts that *imitate* adult technology (as in, say, toy cars, or faux kitchen appliances, or model erector sets). Historically, many toys of the previous century have been based on the assumption (often realistic) that children wish to mimic the work and activities of their elders; thus, a

small child might pick up a toy plastic saw and pretend to do "real" carpentry. This sort of design might be called *imitative* design in that it allows or encourages children to pretend to do adult work.

Imitative design is a factor in many children's toys and games; in such cases, technology (where it occurs) is generally imaginary, fantasy-oriented, or miniaturized. A fantasy toy oven, for instance, might be non-operational, or operate only at safely low (light-bulb-produced) temperatures. In contrast, children's computers are *real* computers; indeed, they are machines of far greater power and versatility than those that Markoff's "high priests" themselves used. Similarly, the adoption of such devices as 3D printers for children represents a true democratization of technology: the printers might be less powerful and high-resolution than their professional cousins, but they are most definitely *real* printers.

There is much more to say about these themes (and others left unmentioned), but for now we can sum up the implications of our discussion for design: namely, that we can look to the professional or industrial world for powerful technologies that can be adapted, without excessive loss of power or performance, to the creative activities of children. The express goal of this sort of design is to expand the creative and intellectual capacities of children–to make their worlds more enjoyable and challenging–while taking due account of the cognitive and physical limitations (and sometimes advantages) of children vis-à-vis adults. The final section of this paper presents an example of the sort of novel design project that we have in mind.

3. AN OPPORTUNITY: A CHILDREN'S PICK-AND-PLACE DEVICE

The previous discussion might conceivably be interpreted as of "theoretical" interest only: having identified a pattern in children's technology, what can we do with it? Our argument is that surfacing such a pattern can act as a springboard for design. As a consequence, we have recently begun work on a child-friendly version of a hitherto "professional" computer-controlled device: a pick-and-place machine. In industrial settings, such devices are employed to rapidly place objects (such as electronic components) onto surfaces with high precision; in essence they are automatic assembly devices for complex multi-part objects. In our " child-oriented" version of pick-and-place, we envision a device that children can program, and through which they can rapidly create complex 3D constructions made of standardized sets of small pieces (such as hexagonal chips, cubic elements, or mosaic tiles). The device is still in its earliest stages (and a paper devoted to its operation is in preparation); but crucially, the impetus for its creation is precisely due to the historical reflections described in this paper. Our goal, in keeping with the earlier discussion, is to place in children's hands a device that can tastefully expand and challenge their creative range. Pick-and-place is just one example of this design heuristic; one might likewise look to the design of novel materials, or (with Dyson) biotechnology as a source of professional technology for adoption. In any event, the transition from professional to children's technology should provide a rich source of inspiration for future designers.

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REFERENCES

Cross, Gary. 1997. *Kids' Stuff.* Cambridge, MA: Harvard University Press.

Dyson, Freeman. 2015. *Dreams of Earth and Sky.* New York: New York Review of Books.

Manes, Rachel. 2009. *Hedonizing Technologies.* Baltimore: Johns Hopkins University Press.

Markoff, John. 2005 *What the Dormouse Said.* New York: Viking.

Mumford, Lewis. 1934. *Technics and Civilization.* San Diego: Harcourt Brace & Company. Harvest edition, 1963.